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(54) Flexible plastics pipe

(57) An axially flexible plastics pipe having a smooth
inner wall 2 and a convoluted outer wall 3, wherein the
ratio of the axial length of a peak of a convolution to the
axial length of a trough between adjacent convolutions is
2 to 4 and wherein the nominal radius of a peak of a
convolution is greater than twice the nominal radius of a
trough between adjacent convolutions. The pipe can be
used for inserting into a service pipe, being capable of
negotiating 90° bends. A method for manufacturing such a
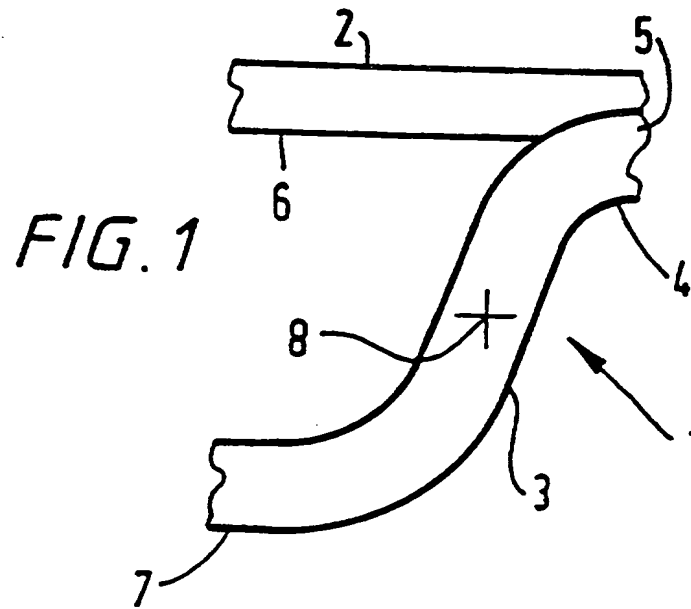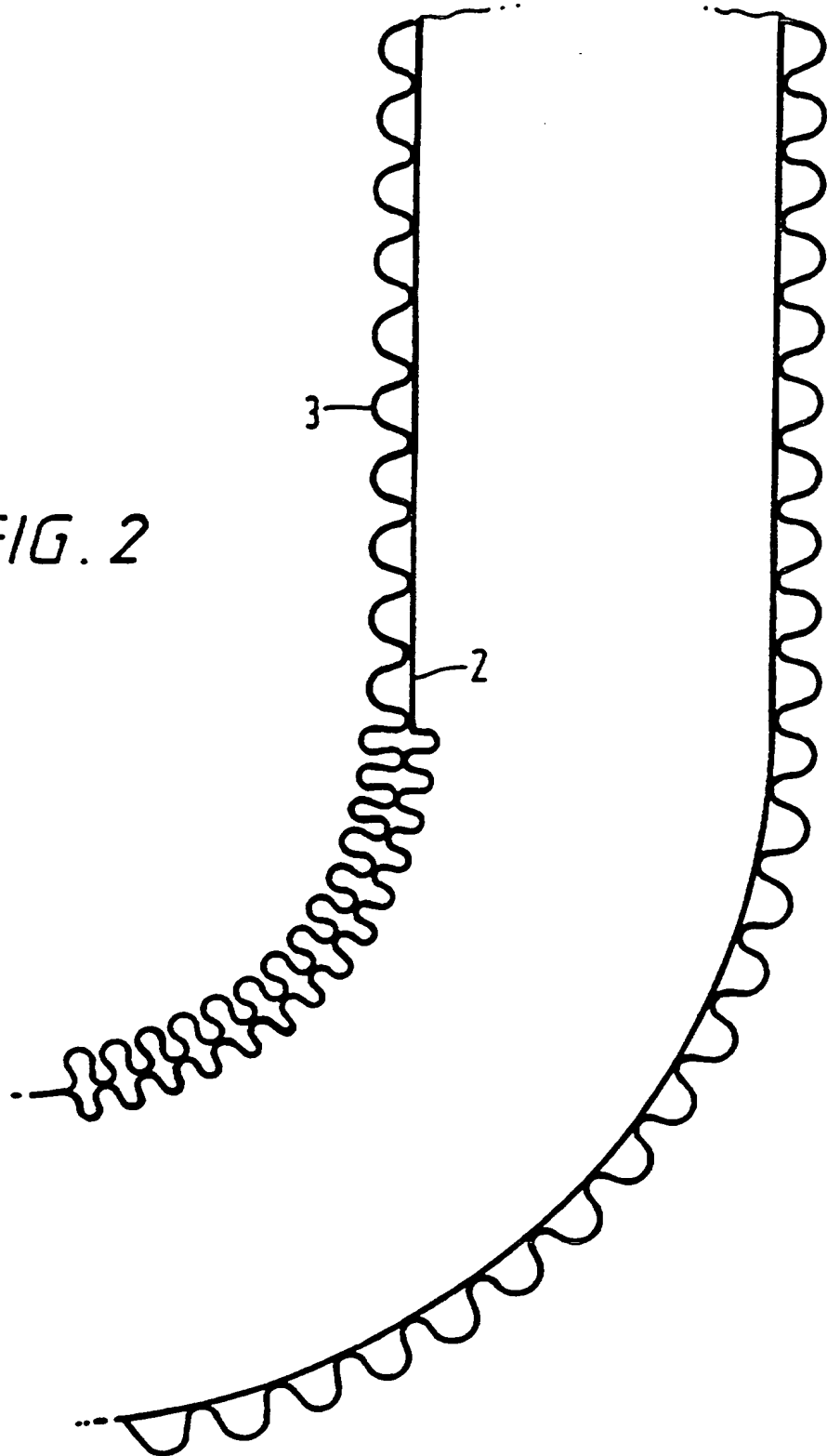pipe is also disclosed.

FIG. 2

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FIG.1

FIG. 2

3
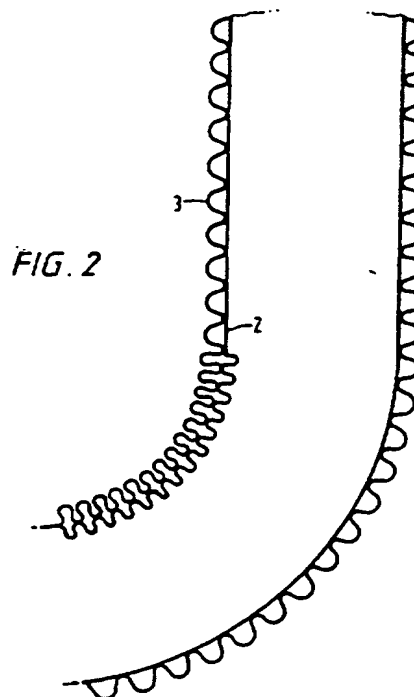
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IMPROVEMENTS IN OR RELATING TO FLEXIBLE PIPES

This invention relates to flexible pipes and is more particularly concerned with a novel flexible plastics
5 pipe and its use in a method for relining or replacing service pipes.

Relining or replacement of corroded, damaged, or fractured service pipes is a major problem for many
10 utility companies. In view of the high cost of renewing service pipes, which frequently involves digging up the entire length of the original pipe in order to lay a new section, various methods for relining or replacing the existing service pipe have been proposed.
15

In UK published patent applications nos. 2227071A, 2236158A, and 2275981A, there are described methods for replacing or relining pipes, particularly domestic gas service pipes, by inserting a replacement pipe into the
20 existing pipe. After the insertion of the replacement pipe, any clearance between the pipes is sealed with a sealant of a flowable, settable type, for example a grout or an anaerobic sealant.

25 The liner or replacement pipe is normally provided with a nose-cone which is connected to the leading end thereof in order to assist the liner or replacement pipe to negotiate any curves or bends in the original pipe

work. The nose-cone is provided with a tubular body having a down-stream portion which is inserted in the leading end of the liner or replacement pipe, and sealing means comprising a series of flanges which form an

5 interference fit with the internal wall of the existing pipe. The flanges stop gas entering the clearance between the pipes and also prevent the sealant from flowing beyond the leading end of the liner or replacement pipe. The nose-cone also has a frangible

10 means to seal the bore of the tubular nose-cone body temporarily, in order to prevent the ingress of gas into the replacement pipe until the repair has been completed. The entire disclosures of the above mentioned patents are incorporated herein by reference for all purposes.

15

The length of service pipe being replaced may be several metres, and there may be several 90° bends over that length. Typically the service pipe to be replaced has an internal diameter of around 25mm, and extends from

20 a service main in the road to a subscriber's premises.

A major obstacle to the widespread introduction of the above relining and replacement systems is the flexibility of the liner or replacement pipe, which, even

25 with the assistance of the nose-cone, can be extremely difficult to insert fully into an existing pipe having a plurality of 90° bends. The liner or replacement pipe must be highly flexible to circumnavigate the bends in

the pipe, and yet be resistant to surface scratches, radial distortion and axial compression. The properties of liner pipes or replacement pipes which have been used hitherto have been a compromise between these conflicting

5 requirements.

The present invention provides a flexible plastics pipe, suitable for relining or replacing an existing service pipe having at least one 90° bend, the flexible

10 pipe having a smooth inner wall and a convoluted outer wall.

In a first aspect, the invention provides an axially flexible plastics pipe having a smooth inner wall and a

15 convoluted outer wall, wherein the ratio of the axial length of a peak of a convolution to the axial length of a trough between adjacent convolutions is 1.5 or greater, and wherein the nominal radius of a peak of a convolution is greater than twice the nominal radius of a trough

20 between adjacent convolutions.

In a second aspect, the invention provides a method of relining or replacing a service pipe in which there is inserted into the service pipe an axially flexible

25 plastics pipe having a smooth inner wall and a convoluted outer wall, wherein the ratio of the axial length of a peak of a convolution to the axial length of a trough between adjacent convolutions is 1.5 or greater, and

wherein the nominal radius of a peak of a convolution is greater than twice the nominal radius of a trough between adjacent convolutions.

5   In a third aspect, the invention provides a method of relining or replacing a service pipe which comprises inserting into the service pipe an axially flexible dual layer plastics pipe, the flexible plastics pipe having a smooth inner wall and a convoluted outer wall, and

10   introducing a sealant into the clearance between the outer wall of the flexible plastics pipe and the service pipe.

The flexible plastics pipe can be of integral

15   construction, but preferably comprises two or more coaxial layers which can be co-extruded, or formed by any other suitable means.   The pipe can, for example, comprise a smooth-walled inner tube and a convoluted outer tube.   In such a construction, the flexibility of

20   the dual layer pipe depends in part upon the connection, if any, between the inner and outer tubes.   Normally each of the troughs of the outer convoluted tube will be fused, welded, adhered, or otherwise anchored to the outer wall of the inner tube, but for increased

25   flexibility it is also possible to arrange that only some of the troughs are anchored to the inner tube.   For example, only alternate troughs of the convoluted tube could be so anchored to the inner tube, in order to give

enhanced flexibility. Preferably the troughs of the outer convoluted tube and the outer wall of the inner tube are fused together, and preferably the total thickness of the fused region is from 0.5 to 1.0, more

5 preferably around 0.8, x the combined nominal wall thickness.

In this specification, the axial length of a peak of a convolution is measured between the points of greatest

10 slope on each side thereof, or, if the sides are straight, the mid-points of the straight sections thereof. The axial length of a trough between adjacent convolutions is measured in a similar fashion between the same points.

15

Preferably the ratio of the axial length of a peak of a convolution to the axial length of a trough between adjacent convolutions is from 2 to 4, for example about 3.

20

The nominal radius of a peak of a convolution is taken as the average radius of the curved section thereof and a nominal radius of a trough between adjacent convolutions is measured similarly.

25

Preferably the nominal radius of a peak of a convolution is from 2 to 4 times the nominal radius of a trough between adjacent convolutions.

The shape of the convolutions is preferably such that in profile the peaks and troughs are curved, for example, in a generally sinusoidal shape, although this is not always essential and in the method of the

5 invention it may sometimes be possible to use convolutions having a substantially triangular (sawtooth), rectangular, or other shaped profile.

The outer diameter of the flexible plastics pipe is

10 preferably such as to be a relatively close fit in the service pipe within which it is to be inserted. Typically, where the service pipe has a bore of 25mm, the flexible plastics pipe will have an outer diameter of around 20mm. In general, the flexible plastics pipe can

15 have any suitable outer diameter, depending on the application, although usually the pipe will have an outer diameter of from 10 to 100mm, for example, from 15 to 50mm.

20 Preferably the height (amplitude) of the convolutions of the outer wall of the flexible pipe is from 0.08 to 0.12 x OD, for example about 0.10 x OD, where OD is the outer diameter of the pipe. Preferably the axial length of a peak of a convolution is from 0.12

25 to 0.15 x OD, for example about 0.125 x OD.

The pitch of the convolutions (peak-to-peak) can be chosen to suit the particular application, but is

preferably from 0.12 to 0.20 x OD. Lengthening the pitch allows more room for the convolutions to compress on the inner radius of a bend, reducing the strain on the outer radius, conversely, shortening the pitch reduces the amount that the inner wall will encroach into the bore of the pipe as if flexes on the inner radius of the bend and hence reduces pressure loss of any fluid in the pipe.

It is important that the flexible plastics pipe should have a smooth inner wall in order to avoid a pressure drop along the pipe when, for example, gas is flowing therethrough. Preferably the depth of any undulation in the inner wall of the pipe is less than 5% of the height of a convolution, when measured on the straight (undeformed) pipe. The variation in bore diameter of the inner wall of the pipe across one pitch of the convolution is preferably no greater than 2.5%, more preferably no greater than 1.5%, of the nominal bore diameter.

The flexible plastics pipe is preferably so constructed that it can relatively easily negotiate the 90° bend in a pipe of only slightly greater diameter than the greatest diameter of the convoluted outer wall. This must of course be achieved without substantial radial deformation of the flexible plastics pipe and preferably without substantial axial compression thereof. Preferably the flexibility of the plastics pipe is such

that when bent to a nominal radius to the centre line of the bend of 1.35 x OD, the ovality at the bend is less than 15% and preferably less than 10%.

5   Where the flexible plastics pipe is of dual layer construction, the inner layer is preferably formed from a plastics material of substantial flexibility, preferably having an elongation at break of greater than 100%, and an elastic modulus of less than 0.5MPa. A 10 preferred material for the inner layer can have, for example, an elongation at break of from 350 to 600%, and an elastic modulus of from 0.2 to 0.7MPa.

The inner layer preferably has a thickness of from 15 0.01 to 0.02 x OD, more preferably about 0.015 x OD. An inner layer wall thickness of from 0.275 to 0.325 mm has been found to be particularly useful.

The outer convoluted layer is preferably also formed 20 from a highly flexible plastics material, and preferably has a flexural modulus of at least 0.8MPa, more preferably from 0.8 to 1.1MPa.

The outer convoluted layer is preferably formed from a 25 plastics material having a thickness of from 0.015 to 0.03 x OD, more preferably about 0.02 x OD. An outer layer wall thickness of from 0.375 to 0.425 mm has been found to be particularly useful.

Both inner and outer layers are preferably formed from plastics materials having substantial stress crack resistance.

5   Both inner and outer layers are preferably of uniform thickness and for example, the thickness of either layer should not vary by more than about 5%.

Where the pipe is of dual layer construction, the

10   annular spaces between the convolutions and the inner tube can be voids, or can be filled with a suitable flexible material, for example, a gel or a rubbery polymeric material.

15   Suitable plastics materials for use in the production of a flexible pipe in accordance with the invention include, for example, polyolefins such as polyethylene and polypropylene, and ethylene copolymers, for example with propylene, butene, hexene, octene, vinyl

20   acetate or other vinyl esters, methyl, ethyl or butyl acrylate; polyamides; polyurethanes; polyvinyl chloride; polyvinylidene fluoride, or other fluorinated polymers or copolymers; and elastomers such as EPDM.

25   The flexible plastics pipe of the invention can be made by any of those methods currently available for the manufacture of convoluted plastics pipes and dual wall plastics pipes. In manufacturing the convoluted outer

wall, an extruded plastics pipe can be heated to its softening point and moulded, for example, by vacuum moulding or blow moulding, or a combination of both, to produce the corrugations. In a further aspect of the
5 invention, a convoluted flexible plastics pipe is manufactured by a method comprising:

(i)   heating the pipe to its softening point;

10 (ii)   surrounding the pipe with one or more mould blocks shaped to produce convolutions;

(iii)   creating a differential pressure between
15   the inside and outside of the pipe such that the pipe is forced into the mould block or blocks to produce the corrugations; and

20 (iv)   adjusting the pressure within the pipe to provide convolutions of the required depth.

Preferably the mould blocks are vacuum mould blocks.
25 In a preferred method in accordance with this aspect of the invention, the pipe is vacuum formed into a convoluted shape, and, after the pipe leaves the mould cavity, the hot gas, usually air, inside the pipe is

allowed to cool such that, as its volume contracts, the differential pressure between the inside and the outside of the pipe serves to stabilise, and/or deepen the convolutions.

5

At least the outer wall or layer of the pipe can, if desired, be cross-linked to give improved abrasion resistance. Cross-linking can be, for example, by irradiation by means of an electron beam, or by a

10 chemical cross-linking method, for example silane cross-linking. A preferred cross-linking method, however, involves incorporating cross-linking initiators into the plastics material and cross-linking by irradiation with ultra-violet light.

15

In a method according to a further aspect of the invention, a flexible dual layer plastics pipe is inserted into a service pipe as a lining or replacement therefor, and a sealant is introduced into the clearance

20 between the flexible pipe and the service pipe. For details of the sealant and procedure used, the reader is referred to the disclosures of UK published patent application nos. 2227071A, 2236158A and 2275981A mentioned heretofore.

25

An embodiment of a flexible plastics pipe according to the invention will now be described with reference to the accompanying Drawings, in which:

Figure 1 shows an axial section through a wall of a dual layer pipe according to the invention in an undeformed condition; and

5   Figure 2 shows a section through the same pipe when fully compressed by axial bending as would occur on the inner radius when the pipe is inserted into a 90° bend in a service pipe.

10   Referring first to Figure 1, the dual layer pipe illustrated generally at 1 comprises an inner smooth bore flexible tube 2 and an outer convoluted tube 3. The pipe 1 has an outer diameter of 20mm and an inner diameter of 15mm and is intended to be capable of bending in a 90°

15 sharp bend inside a pipe bore of 25mm. The inner tube 2 has a wall thickness of 0.3mm and the convoluted outer tube 3 has a wall thickness of 0.40mm.

The trough 4 of the convoluted outer tube is

20 anchored at 5 to the outer wall 6 of the inner tube 2 for example by welding.

As illustrated, the axial length of the peak of the convolution 7 is 2.25mm measured from the midpoint 8 and

25 the axial length of the trough 4 is 1.15mm, giving a ratio of 3.0. The nominal radius of the peak of the convolution 7 is 1.15mm measured from the outer wall and

the nominal radius of the trough 4 is 0.3mm, measured from the inner wall, giving a ratio of 3.8 to 1.

The pitch of the convolutions of the flexible pipe
5   is 3.4mm on an OD of 20mm.

Referring now to Figure 2, there is shown the configuration of the flexible pipe 1 when subjected to
10 compression by axial bending, as would occur, for example, on the inside radius of the bend.   It can be observed that the effect of compression is to force the flexible inner tube 2 to flex into the pipe bore thus allowing more compression on the inner bend radius,
15 reducing the strain on the outer radius of the bend and hence reducing any effect on ovality.

Plastics pipes in accordance with the invention may find a wide variety of applications in relining service
20 pipes of all types.   The pipes of the invention can be particularly useful in the relining and replacement of pipes carrying a fluid under pressure, and especially domestic gas service pipes.

25   The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this

specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification

5 (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

10

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless

15 expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

20 The invention is not restricted to the details of the foregoing embodiment(s). This invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any

25 novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. An axially flexible plastics pipe having a smooth
    inner wall and a convoluted outer wall, wherein the
    ratio of the axial length of a peak of a convolution
    to the axial length of a trough between adjacent
    convolutions is 1.5 or greater, and wherein the
    nominal radius of a peak of a convolution is greater
    than twice the nominal radius of a trough between
    adjacent convolutions.

2. A pipe according to Claim 1, which comprises two or
    more coaxial layers.

3. A pipe according to Claim 1 or 2, which comprises a
    smooth-walled inner tube and a convoluted outer
    tube.

4. A pipe according to Claim 3, in which the troughs of
    the outer convoluted tube are fused, welded,
    adhered, or otherwise anchored to the outer wall of
    the inner tube.

5. A pipe according to Claim 4, in which only some of
    the troughs of the outer convoluted tube are
    anchored to the inner tube.

6. A pipe according to any of the preceding claims, in which the ratio of the axial length of a peak of a convolution to the axial length of trough between adjacent convolutions is from 2 to 4.

5

7. A pipe according to any of the preceding claims, in which the nominal radius of a peak of a convolution is from 2 to 4 times the nominal radius of a trough between adjacent convolutions.

10

8. A pipe according to any of the preceding claims, in which, in profile, the peaks and troughs are curved in a generally sinusoidal shape.

15 9. A pipe according to any of the preceding claims, in which the height (amplitude) of the convolutions of the outer wall is from 0.08 to 0.12 x OD, where OD is the outer diameter of the pipe.

20 10. A pipe according to any of the preceding claims, in which the axial length of a peak of a convolution is from 0.12 to 0.15 x OD.

11. A pipe according to any of the preceding claims, in which the pitch of the convolutions (peak-to-peak)
25 is preferably from 0.12 to 0.20 x OD.

12. A pipe according to any of the preceding claims, in which the depth of any undulation in the inner wall is less than 5% of the height of a convolution, when measured on the undeformed pipe.

5

13. A pipe according to any of the preceding claims, having a flexibility such that when bent to a nominal radius to the centre line of the bend of 1.35 x OD, the ovality at the bend is less than 15%.

10

14. A pipe according to any of the preceding claims, which is of dual layer construction and has an inner layer formed from a plastics material having an elongation at break of greater than 100%, and an elastic modulus of less than 0.5 MPa.

15

15. A pipe according to Claim 14, in which the material of the inner layer has an elongation at break of from 350 to 600% and an elastic modulus of from 0.2 to 0.7 MPa.

20

16. A pipe according to any of the preceding claims, that is of dual layer construction and has an inner layer having a thickness of from 0.01 to 0.02 x OD.

25

17. A pipe according to any of the preceding claims, that is of dual layer construction, and has an outer

convoluted layer having a flexural modulus of from 0.8 to 1.1 MPa.

18.   A pipe according to any of the preceding claims, that is of dual layer construction and has an outer convoluted layer formed from a plastics material having a thickness of from 0.015 to 0.03 x OD.

19.   A pipe according to any of the preceding claims, that is of dual layer construction, and wherein the annular spaces between the convolutions and the inner tube are filled with a gel or a rubbery polymeric material.

20.   A pipe according to any of the preceding claims, that is of dual layer construction, and wherein at least one of the inner and outer layers comprises polyethylene.

21.   A pipe according to any of the preceding claims, wherein at least the outer wall or layer thereof has been cross-linked.

22.   A pipe according to any of the preceding claims, substantially as hereinbefore described with reference to and as illustrated in the accompanying Drawings.

23. A flexible convoluted plastics pipe having a smooth inner wall substantially as hereinbefore described.

24. A method of relining or replacing a service pipe in which there is inserted into the service pipe an axially flexible plastics pipe having a smooth inner wall and a convoluted outer wall, wherein the ratio of the axial length of a peak of a convolution to the axial length of a trough between adjacent convolutions is 1.5 or greater and wherein the nominal radius of a peak of a convolution is greater than twice the nominal radius of a trough between adjacent convolutions.

25. A method according to Claim 24 in which there is used a pipe according to any of Claims 1 to 23.

26. A method according to Claim 24 or 25 substantially as hereinbefore described.

27. A method of relining or replacing a service pipe which comprises inserting into the service pipe an axially flexible dual layer plastics pipe, the flexible plastics pipe having a smooth inner wall and a convoluted outer wall, and introducing a sealant into the clearance between the outer wall of the flexible plastics pipe and the service pipe.

28. A method according to Claim 27 in which there is used a pipe according to any of Claims 1 to 23.

29. A method according to Claim 27 or 28 substantially as hereinbefore described.

30. A convoluted flexible plastics pipe produced by a method comprising:

(i)   heating the pipe to its softening point;

(ii)   surrounding the pipe with one or more mould blocks shaped to produce convolutions;

(iii)   creating a differential pressure between the inside and outside of the pipe such that the pipe is forced into the mould block or blocks to produce the corrugations; and

(iv)   adjusting the pressure within the pipe to provide convolutions of the required depth.

31. A method according to Claim 30 in which the mould blocks are vacuum mould blocks.

32. A method according to Claim 30 or 31, in which the pipe is vacuum formed into a convoluted shape, and, after the pipe leaves the mould cavity, the hot gas inside the pipe is allowed to cool such that, as its volume contracts, the differential pressure between the inside and the outside of the pipe serves to stabilise, and/or deepen the convolutions.

33. A method according to any of Claims 30 to 32 substantially as hereinbefore described.

34. A flexible plastics pipe, suitable for relining or replacing an existing service pipe having at least one 90° bend, the flexible pipe having a smooth inner wall and a convoluted outer wall.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The _ _rch report)

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Relevant Technical Fields	**Search Examiner** MR S WALLER
(i) UK Cl (Ed.N) F2P PC3	
(ii) Int Cl (Ed.6) F16L 9/06, 11/11	**Date of completion of Search** 7 JULY 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications.	**Documents considered relevant following a search in respect of Claims :-** 1-26, 30-34
(ii) ONLINE: WPI	

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X,Y	GB 1525450	(HEGLER) see Figures 2, 3 and 6 to 8, page 1 lines 83 to 87 page 3 lines 27 to 35 and lines 68 to 73	1, 2, 3, 4, 20, 34 19
X,Y	WO 87/05376	(JOHANSSON) see Figure 1, page 2 line 22 to page 3 line 26	1, 2, 3, 4, 8, 20, 24, 25, 34 19
X,Y	EP 0213674	(WAVIN) see column 3 lines 40 to 47	34 19

Databases:The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Jou͗
(Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).